Virginia Department of Environmental Quality (VDEQ)

The Virginia Mercury Study: Review and Assessment of Virginia Mercury Emissions Data and Recent Mercury Studies

Mercury Modeling Study Contract № 13360 Report

September 2007

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Virginia Department of Environmental Quality (VDEQ)

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1. Introduction

This report summarizes a review and analysis of the sources of atmospheric mercury emissions located within the Commonwealth of Virginia and surrounding areas. This review was conducted as part of the Virginia Mercury Study, which includes an air quality modeling analysis focusing on mercury air deposition to waterways.

1.1. Background

Mercury in the atmosphere can be attributed to both natural and anthropogenic sources. Natural sources of mercury include soils, rocks, volcanoes, and the oceans. Within the U.S., most natural mercury emissions are associated with land types found in the western part of the continent. Prescribed burning and wild fires, which occur in many different areas throughout the U.S., can cause re-emission of natural and previously deposited emissions into the atmosphere.

Anthropogenic sources of mercury include coal-fired power plants and other industrial coal-burning facilities, municipal, medical, industrial and hazardous waste incinerators, chlor-alkali and other chemical manufacturing plants, taconite and other metallurgical processing facilities, pulp and paper manufacturing facilities, mining operations, cement plants, mobile sources, and a wide variety of other industrial and residential sources (EPA, 2005a).

Recent national control legislation promulgated by EPA in the Clean Air Interstate Rule (CAIR) will serve to reduce emissions of NO_x, SO_2, and mercury from coal-fired power plants. The Clean Air Mercury Rule (CAMR) will build on CAIR and provide for additional future mercury emission reductions from these sources. Although controls have been mandated for a number of Virginia coal-fired power plant sources, an air quality modeling analysis will be conducted to quantify the effects of these controls on future-year mercury concentrations and deposition to waterways in the Commonwealth and to determine if more controls are needed.

Recently, the Virginia Department of Environmental Quality (VDEQ) updated the statewide mercury point source emission inventory and developed inventories for 2002 and 2005. These inventories were updated using information received from 75 facilities based on a survey. The information received from each of the facilities was reviewed in this analysis and will be used to estimate future-year emissions. The future-year estimates will be used in the air quality modeling and deposition analysis.

1.2. Objectives

The objectives of this portion of the Virginia Mercury Study are to: 1) conduct a review and analysis of recently updated mercury point source information for sources located in Virginia that will subsequently be used in the air deposition analysis, 2) estimate future-year emissions for 2010, 2015, and 2018 for these sources, and 3) conduct a literature search of recently completed mercury studies related to air deposition, emissions/controls, and air quality modeling and modify the planned approach to the modeling analysis, if warranted, to take advantage of the latest science related to mercury deposition modeling. The first two objectives ensure that the best available mercury emissions inventory is used for the base and future-year modeling analyses, while the third objective ensures that the air deposition modeling analysis will be conducted using the latest available modeling tools and approaches.

1.3. Atmospheric Mercury

Airborne mercury (Hg), emitted from various manmade and natural sources, is comprised of three forms: elemental mercury (Hg(0)), reactive gaseous mercury (RGM), and particulate mercury (Hg(p)). RGM is known to be comprised almost entirely of divalent mercury (Hg^{2+} or Hg(II)), since mercury compounds at other valence states tend to be chemically unstable in the atmosphere (Bullock et al., 2007). Hg(p) is also primarily comprised of divalent mercury, but may also include elemental mercury.

Elemental mercury is the dominant atmospheric species and comprises about 99 percent of the total mercury in the atmosphere. Hg(0) is characterized by low reactivity and low solubility in water. The dry deposition velocity is believed to be relatively low. Hg(0) has a long atmospheric lifetime (perhaps on the order of months to years) and is therefore dispersed and transported/circulated globally.

RGM represents less than one percent of atmospheric mercury. It is highly reactive and highly soluble. It can be actively removed from the atmosphere through both wet and dry deposition processes. As a result, the atmospheric lifetime of RGM is expected to be on the order of one day to one week. Based on these properties, RGM likely contributes to mercury deposition near the source location (locally or regionally).

Hg(p) also represents less than one percent of atmospheric mercury. It is moderately reactive and highly soluble in water. It is likely removed from the atmosphere primarily through wet deposition, since the dry deposition velocity of Hg(p) is expected to be low (based on that for similar fine particles). The atmospheric lifetime of Hg(p) is estimated to be on the order of one day to one week, or longer in the absence of precipitation. Based on these properties, Hg(p) also likely contributes to mercury deposition near the source location (locally or regionally).

1.4. Report Outline

Section 2 of this report summarizes the review of the Virginia point source inventory and Section 3 summarizes the base- and future-year estimates that will be used for the modeling analysis. Section 4 presents a summary of recent mercury studies that were reviewed as part of the literature search task. Finally, a comprehensive bibliography of recently completed reports and presentations is provided in the Appendix.

2. Overview of the Virginia Point Source Inventory

2.1. Review of 2002 Point Source Inventory

This section provides an overview of the process followed in reviewing and updating the mercury point source emissions inventory. As part of this study, point source inventories for 2002 and 2005 were obtained from VDEQ. These inventories were recently compiled based on responses to an information survey conducted by VDEQ to obtain the latest available emission inventory data for mercury point sources located in Virginia. Information regarding process type, emission totals, and mercury speciation was solicited and obtained. For those sources that did not have any speciation information based on recent stack testing, VDEQ instructed them to specify the default speciation profiles that were used in EPA's CAMR modeling analysis.

The intent of this review was to evaluate the information and identify missing data that, if updated, would improve the overall quality of the emission inventory. As noted, the 2002 emission inventory will be used in the base-year air quality modeling analysis and will be the basis for development of the future-year mercury emission inventories, so it is important to review the information and make any changes necessary to ensure that the latest and best information be made available for the modeling analysis.

In February 2007, a CD was received from VDEQ containing emission inventory files for seventy-five Virginia point sources. Of the facilities included, thirty-four supplied complete information and forty-one facilities had some missing or questionable information. Below, we summarize the findings of the initial review of the inventory.

The following table outlines the completeness of the initial responses to the DEQ data request.

	Number of Facilities
VDEQ potential source list	75
Supplied complete information	34
No information was supplied	5
Emissions rates incomplete	6
Speciation data incomplete	15
Stack parameter information incomplete	15
General source information incomplete	10

Detailed information for each category of missing data/information is provided below. Updates received from VDEQ for each of these categories are italicized in each of the sections.

No Information Provided

Information for five facilities on VDEQ's original list of potential mercury facilities was not included in the emission inventory. The facilities, along with the Virginia registration number, include:

1.	UVA Medical Center	40359
2.	Tangier Town	40714
3.	Perdue Farms–Soybean Oil Processing	60277
4.	Norman M Cole Jr Pollution Control Plant	70714
5.	Merck & Co	80524

Upon review by VDEQ, the UVA Medical Center and the Merck & Co. sources were removed from the list of potential mercury emitters. The Tangier Town and Norman M Cole Jr Pollution Control Plant sources were deemed insignificant sources of mercury. New emissions for the Perdue Farms source were provided by VDEQ.

Incomplete Emissions Information

Mercury emission rates were missing or questionable for six of the facilities. The equations and approach to determining the emission rates varied appreciably – approaches included AP-42, mass balance, stack test data, SW-486 and NCASI. In many cases, no supporting calculations are provided. Facilities with missing mercury emission rate information include:

1.	RES dba Steel Dynamics	20131	*Provided total Hg emissions for plant*
2.	Rock Tenn Co Mill	30188	*No updates provided*
3.	Dominion–Mecklenburg Power Station	30861	*Added new Hg emissions*
4.	Philip Morris USA Inc–Park 500	50722	*No updates provided*
5.	Burlington Industries LLC Hurt Fin	30379	*Added new Hg emissions*
6.	Stone Container Enterprises (Smurfit)	40126	*Confirmed that three stacks in facility have no Hg emissions*

Specific updates, as noted in the list above, were provided by VDEQ for these sources.

Speciation Information

Speciation information was missing for fifteen of the facilities. Facilities with speciation information missing included:

1.	MeadWestvaco Packaging Resources	20328
2.	RES dba Steel Dynamics	20131
3.	Philip Morris USA Mfg Center	50076
4.	Hopewell WWTP	50735
5.	James River Cogeneration Company	50950

6.	Spruance Genco LLC	51033
7.	Cogentrix Virginia Leasing Corp	61049
8.	H L Mooney Water Reclamation Facility	71751
9.	Georgia Pacific Corp Big Island Plt	30389
10.	Honeywell Nylon LLC–Hopewell	50232
11.	Philip Morris USA Inc.–Blended Leaf	50080
12.	Philip Morris USA Inc.–Leaf Processing	50082
13.	Burlington Industries LLC Hurt Fin	30379
14.	Griffin Pipe Products Company	30397
15.	Stone Container Enterprises (Smurfit)	40126

New information on mercury speciation profiles was obtained from VDEQ for all of these sources.

Incomplete Stack Parameter Information

Stack parameter information for fifteen facilities was initially incomplete or questionable. The deficient information ranged from missing geographic location, questionable entries, and missing physical stack parameters. Facilities with stack parameter information missing include:

1.	MeadWestvaco Packaging Resources	20328
2.	Dominion–Mecklenburg Power Station	30861
3.	Dominion–Clover Power Station	30867
4.	Birchwood Power Partners, L.P.	40809
5.	Honeywell Nylon LLC–Hopewell	50232
6.	Stone Container Corporation–Hopewell	50370
7.	Philip Morris USA Inc–Park 500	50722
8.	City of Harrisonburg– Resource Recovery	81016
9.	Dan River Incorporated Schoolfield	30240
10.	University of Virginia	40200
11.	US Navy Little Creek Amphibious Base	60033
12.	Burlington Industries LLC Hurt Fin	30379
13.	Griffin Pipe Products Company	30397
14.	Stone Container Enterprises (Smurfit)	40126
15.	Hopewell Cogeneration Ltd Partnership	50967

New stack information was obtained from VDEQ for all of these sources.

Incomplete General Information

General emission unit information for ten facilities was incomplete or questionable. Primarily this included SCC and MACT codes. In many cases, it was not clear whether the sources met the requirements for MACT. It was not possible to tell if all emission sources for the individual facilities were included in the preliminary inventory. Facilities with incomplete general emission unit information included:

1. Virginia Tech 20124
2. MeadWestvaco Virginia Specialty 20329
3. Internet Foundry Archer Creek 30121
4. Solite LLC/Giant Resource Recovery 30200
5. Burlington Industries LLC Hurt Fin 30379
6. Georgia Pacific Corp Big Island Plt 30389
7. Griffin Pipe Products Company 30397
8. Stone Container Enterprises (Smurfit) 40126
9. Hopewell Cogeneration Ltd Partnership 50967
10. Mohawk Industries Inc-Lees Carpet 80269

New information was obtained from VDEQ for all of these sources.

Specific Information Requested for Updating the Virginia Point Source Inventory

In addition to the general missing information related to emissions and stack parameters identified above, efforts were made to obtain the following information:

1. SCC codes for the following facilities.
    a. Chemical Lime Company 20225
    b. Celanese/Cinergy Solutions (21418) 20304
    c. Commonwealth Chesapeake Power 40898
    d. James River Cogeneration Company 50950
    e. Spruance Genco LLC 51033
    f. Cogentrix Virginia Leasing Corp 61049

New SCC code information was obtained from VDEQ for all of these sources.

2. Verify that the mercury speciation profiles for the following electric generating units (EGUs), which were specified as default 20/30/50 (hgp/hg2/hg0), are the latest available (or obtain updated profiles, if available).
    a. Dominion–Altavista Power Station 30859
    b. Dominion–Clover Power Station 30867
    c. Dominion–Bremo 40199

d. Dominion–Gordonsville Power Station 40808
e. Dominion–Chesterfield Power Station 50396
f. Dominion–Yorktown Power Station 60137
g. Dominion–Chesapeake Energy Center 60163
h. Dominion–Southampton Power Station 61093
i. Dominion–Elizabeth River CT Station 61108
j. Dominion–Possum Point Power Station 70225
k. Covanta Alexandria/Arlington, Inc. 71895
l. Covanta Fairfax, Inc. 71920

No new facility-specific speciation profile information was available for any of these sources.

2.2. Updated 2002 Point Source Inventory

Based on the initial review of the inventory as summarized in the previous section, updated information was received from VDEQ. Table 2-1 presents the final 2002 Virginia mercury point source inventory, summarized by facility. The table includes speciated emissions for EGU's and non-EGU's (other industrial sources) and the sources are listed in descending order by total facility mercury emissions. As noted above, for those sources that did not obtain any speciation information based on recent stack testing, they were instructed by VDEQ to specify the default speciation profiles that were used in EPA's CAMR modeling analysis (EPA, 2005a).

Table 2-1 VDEQ 2002 Point Source Mercury Emissions Inventory—Ranked by Facility Total Emissions

	Facility Name	County	Source Type	HG0 (lb/yr)	HG2 (lb/yr)	HGP (lb/yr)	*Total (lb/yr)*
1	Dominion–Chesterfield Power Station	Chesterfield	EGU	179.42	107.65	71.77	*358.83*
2	Jewel Coke Company LLP	Buchanan	non-EGU	271.67	33.96	33.96	*339.59*
3	Chaparral Steel	Dinwiddie	non-EGU	233.75	29.29	29.26	*292.30*
4	Dominion–Bremo	Fluvanna	EGU	83.86	50.32	33.55	*167.73*
5	American Electric Power- Clinch River	Russell	EGU	38.21	121.00	0.00	*159.21*
6	Dominion–Chesapeake Energy Center	Chesapeake	EGU	78.69	47.22	31.48	*157.38*
7	Potomac River Generating Station	Alexandria	EGU	11.83	106.43	0.00	*118.26*
8	Dominion–Yorktown Power Station	York	EGU	53.82	32.29	21.53	*107.64*
9	Dominion-Possum Point Power Station	Prince William	EGU	50.09	30.06	20.04	*100.19*
10	Stone Container Enterprises (Smurfit)	King William	non-EGU	46.81	27.22	3.73	*77.76*
11	Stone Container Corporation -Hopewell	Hopewell	non-EGU	34.84	20.91	13.94	*69.69*
12	American Electric Power	Giles	EGU	26.06	39.08	0.00	*65.14*
13	Intermet Foundry Archer Creek	Campbell	non-EGU	51.97	6.53	6.51	*65.01*
14	RES dba Steel Dynamics	Roanoke	non-EGU	48.64	6.08	6.08	*60.80*
15	Spruance Genco LLC	Richmond	EGU	27.75	16.65	11.10	*55.50*
16	Mead Westvaco Packaging Resources	Covington	non-EGU	12.96	4.88	9.07	*26.91*
17	Covanta Fairfax, Inc.	Fairfax	EGU	12.87	7.72	5.15	*25.73*
18	James River Cogeneration Company	Hopewell	EGU	12.65	7.59	5.06	*25.30*
19	Celanese/Cinergy Solutions (21418)	Giles	non-EGU	9.20	5.52	3.68	*18.40*
20	Dominion–Clover Power Station	Halifax	EGU	8.34	5.00	3.34	*16.68*
21	Giant Yorktown Refinery	York	non-EGU	12.74	1.59	1.59	*15.93*
22	SPSA Refuse Derived Fuel Plant	Portsmouth	non-EGU	3.43	9.05	3.12	*15.61*
23	H L Mooney Water Reclamation Facility	Prince William	non-EGU	3.21	8.47	2.92	*14.61*
24	Hopewell WWTP	Hopewell	non-EGU	2.93	7.71	2.66	*13.30*
25	HRSD Chesapeake-Elizabeth Sewage	Virginia Beach	non-EGU	2.87	7.56	2.61	*13.04*
26	Cogentrix Virginia Leasing Corp	Portsmouth	EGU	5.85	3.51	2.34	*11.70*
27	Chemical Lime Company	Giles	non-EGU	9.20	1.15	1.15	*11.50*
28	Burlington Industries LLC Hurt Fin	Pittsylvania	non-EGU	5.53	3.32	2.21	*11.05*
29	HRSD Boat Harbor Sewage Treatment Plt	Newport News	non-EGU	2.11	5.56	1.92	*9.59*
30	Roanoke Cement Company	Botetourt	non-EGU	6.96	1.21	1.11	*9.28*
31	Alliant Ammunition & Powder Co.	Montgomery	non-EGU	4.57	2.74	1.83	*9.14*
32	Philip Morris USA Inc–Park 500	Chesterfield	non-EGU	4.35	2.61	1.74	*8.69*
33	Georgia Pacific Corp Big Island Plt	Bedford	non-EGU	3.84	2.30	1.53	*7.67*
34	Mohawk Industries Inc-Lees Carpet	Rockbridge	non-EGU	3.76	2.26	1.50	*7.52*
35	HRSD Virginia Initiative Plant	Norfolk	non-EGU	1.45	3.81	1.31	*6.57*
36	HRSD Army Base Sewage Treatment Plt	Norfolk	non-EGU	1.41	3.71	1.28	*6.40*
37	Intermet Corporation Radford	Radford	non-EGU	4.90	0.61	0.61	*6.12*
38	Bear Island Paper Company LLC	Hanover	non-EGU	2.96	1.77	1.18	*5.91*
39	US Navy Little Creek Amphibious Base	Virginia Beach	non-EGU	2.93	1.76	1.17	*5.87*
40	HRSD Williamsburg	James City	non-EGU	0.99	2.62	0.90	*4.51*
41	Georgia-Pacific/Emporia Plywood	Greensville	non-EGU	2.06	1.24	0.82	*4.12*

	Facility Name	County	Source Type	HG0 (lb/yr)	HG2 (lb/yr)	HGP (lb/yr)	*Total (lb/yr)*
42	Covanta Alexandria/Arlington, Inc.	Alexandria	EGU	1.96	1.17	0.78	*3.92*
43	Dan River Incorporated Schoolfield	Danville	non-EGU	1.86	1.11	0.74	*3.71*
44	International Paper Company	Isle Of Wight	non-EGU	1.82	1.09	0.73	*3.63*
45	Honeywell Nylon LLC–Hopewell	Hopewell	non-EGU	1.81	1.09	0.72	*3.62*
46	Birchwood Power Partners, L.P.	King George	EGU	1.41	2.05	0.13	*3.59*
47	Solite LLC/Giant Resource Recovery	Buckingham	non-EGU	1.45	0.50	0.55	*2.50*
48	University of Virginia	Charlottesville	non-EGU	1.25	0.75	0.50	*2.49*
49	Philip Morris USA Mfg Center	Richmond	non-EGU	1.24	0.74	0.50	*2.48*
50	Dominion-Southampton Power Station	Southampton	EGU	1.10	0.66	0.44	*2.19*
51	Dominion–Altavista Power Station	Campbell	EGU	1.09	0.65	0.44	*2.18*
52	O-N Minerals (Chemstone) Strasburg	Shenandoah	non-EGU	1.74	0.22	0.22	*2.17*
53	Rock Tenn Co Mill	Lynchburg	non-EGU	0.94	0.56	0.37	*1.87*
54	Virginia Tech	Montgomery	non-EGU	0.75	0.45	0.30	*1.49*
55	Martinsville Thermal, LLC	Henry	non-EGU	0.71	0.42	0.28	*1.41*
56	Commonwealth Chesapeake Power	Accomack	EGU	0.67	0.40	0.27	*1.34*
57	Dominion–Mecklenburg Power Station	Mecklenburg	EGU	0.84	0.25	0.03	*1.11*
58	Hopewell Cogeneration Ltd Partnership	Hopewell	non-EGU	0.53	0.32	0.21	*1.05*
59	INVISTA S.a.r.l. -Waynesboro	Waynesboro	non-EGU	0.52	0.31	0.21	*1.04*
60	Dominion–Gordonsville Power Station	Louisa	EGU	0.41	0.25	0.16	*0.82*
61	Griffin Pipe Products Company	Lynchburg	non-EGU	0.57	0.07	0.07	*0.71*
62	O-N Minerals (Chemstone) Clearbrook	Frederick	non-EGU	0.32	0.04	0.04	*0.40*
63	Hampton/NASA Steam Plant	Hampton	non-EGU	0.07	0.17	0.06	*0.30*
64	Perdue Farms–Soybean Oil Processing	Chesapeake	non-EGU	0.13	0.08	0.05	*0.26*
65	Philip Morris USA Inc.–Leaf Processing	Richmond	non-EGU	0.10	0.06	0.04	*0.20*
66	Mead Westvaco Virginia Specialty	Covington	non-EGU	0.07	0.01	0.01	*0.09*
67	Blacksburg Sanitation Authority	Montgomery	non-EGU	0.01	0.03	0.01	*0.06*
68	Philip Morris USA Inc.–Blended Leaf	Richmond	non-EGU	0.03	0.02	0.01	*0.05*
	Total			*1,404.81*	*793.43*	*352.62*	*2,550.86*

2.3. Comparison of 2002 Virginia Inventory with the NEI

The EPA compiles and maintains a national inventory of mercury emissions as contained in the National Emission Inventory (NEI). As part of this task, the latest version (Version 3) of the 2002 NEI mercury inventory was obtained from EPA. This inventory contains information for point sources and "non-point" sources, also referred to as area sources. These include various other types of fuel combustion sources that emit mercury. The NEI inventory obtained from EPA contains mercury emissions information for 379 distinct Virginia facilities. The top 25 of these sources represent 97 percent of total point source mercury emissions, so there are a number of facilities in this inventory with very small mercury emissions, the majority of which are landfills that emit less than 1 lb of mercury per year. The 2002 Virginia DEQ mercury point source inventory contains information for 68 facilities. The top 25 of these sources represent 93 percent of total point source mercury emissions. A number of the smaller facilities emit less than 5 lbs of mercury per year.

Table 2-2 presents a comparison of emissions for the 68 point sources contained in the updated Virginia inventory with those same sources contained in the NEI inventory. The table includes speciated emissions for elemental, divalent, and particulate mercury based on total mercury, and the assumed speciation profile for each source. The table shows some similarities in emissions totals but also major differences in emissions for a number of the top mercury point source emitters in Virginia. In addition, there are some differences in the assumed speciation profile for a number of sources. It is not evident why the emissions for some of the sources are different or why there are differences in assumed speciation profiles. It is assumed that the updated Virginia inventory includes the latest and most accurate information for these sources. The table also shows that some of the top mercury point sources in Virginia are not included in the current national inventory. Conversely, there are a number of moderate-sized sources listed in the NEI that are not included in the Virginia inventory and it was found that some of the sources in the NEI were closed prior to 2002. It is not clear why certain sources are missing from the NEI or why a few of the closed sources are still included, however, it is expected that emissions for Virginia's updated mercury point source inventory will be submitted to EPA, along with changes/corrections/shutdowns to any other Virginia source in the existing NEI, for inclusion in the next version of the NEI.

Table 2-2. Comparison of Mercury Emitters in the 2002 VDEQ Point Source Inventory with those same sources in the 2002 NEI Version 3 Inventory

	Facility Name	County	Source Type	Updated VDEQ Inventory							EPA 2002 NEI Version 3 Inventory						
				2002 Emissions				Speciation			2002 Emissions				Speciation		
				HG0 (lb/yr)	HG2 (lb/yr)	HGP (lb/yr)	Total (lb/yr)	HG0	HG2	HGP	HG0 (lb/yr)	HG2 (lb/yr)	HGP (lb/yr)	Total (lb/yr)	HG0	HG2	HGP
1	Dominion - Chesterfield Power Station	Chesterfield	EGU	179.42	107.65	71.77	358.83	50%	30%	20%	114.42	303.62	27.19	445.23	26%	68%	6%
2	Jewel Coke Company LLP	Buchanan	non-EGU	271.67	33.96	33.96	339.59	80%	10%	10%	271.67	33.96	33.96	339.59	80%	10%	10%
3	Chaparral Steel	Dinwiddie	non-EGU	233.75	29.29	29.26	292.30	80%	10%	10%	312.79	39.10	39.10	390.98	80%	10%	10%
4	Dominion - Bremo Power Station	Fluvanna	EGU	83.86	50.32	33.55	167.73	50%	30%	20%	59.72	92.67	7.87	160.26	37%	58%	5%
5	American Electric Power- Clinch River	Russell	EGU	38.21	121.00	0.00	159.21	24%	76%	0%	41.74	110.76	9.92	162.42	26%	68%	6%
6	Dominion - Chesapeake Energy Center	Chesapeake	EGU	78.69	47.22	31.48	157.38	50%	30%	20%	46.98	124.65	11.16	182.79	26%	68%	6%
7	Potomac River Generating Station	Alexandria	EGU	11.83	106.43	0.00	118.26	10%	90%	0%	18.62	49.40	4.42	72.45	26%	68%	6%
8	Dominion - Yorktown Power Station	York	EGU	53.82	32.29	21.53	107.64	50%	30%	20%	40.07	87.88	10.98	138.93	29%	63%	8%
9	Dominion-Possum Point Power Station	Prince William	EGU	50.09	30.06	20.04	100.19	50%	30%	20%	36.88	89.43	9.43	135.74	27%	66%	7%
10	Stone Container Enterprises (Smurfit)	King William	non-EGU	46.81	27.22	3.73	77.76	60%	35%	5%	0.03	0.02	0.01	0.06	50%	30%	20%
11	Stone Container Corporation - Hopewell	Hopewell	non-EGU	34.84	20.91	13.94	69.69	50%	30%	20%	33.70	20.22	13.48	67.39	50%	30%	20%
12	American Electric Power - Glen Lyn	Giles	EGU	26.06	39.08	0.00	65.14	40%	60%	0%	19.59	51.98	4.65	76.22	26%	68%	6%
13	Intermet Foundry Archer Creek	Campbell	non-EGU	51.97	6.53	6.51	65.01	80%	10%	10%	0.80	0.10	0.10	1.00	80%	10%	10%
14	RES dba Steel Dynamics	Roanoke	non-EGU	48.64	6.08	6.08	60.80	80%	10%	10%	185.07	23.13	23.13	231.33	80%	10%	10%
15	Spruance Genco LLC	Richmond	EGU	27.75	16.65	11.10	55.50	50%	30%	20%	3.77	1.09	1.21	6.08	62%	18%	20%
16	Mead Westvaco Packaging Resources	Covington	non-EGU	12.96	4.88	9.07	26.91	48%	18%	34%	0.45	0.27	0.18	0.89	50%	30%	20%
17	Covanta Fairfax, Inc.	Fairfax	EGU	12.87	7.72	5.15	25.73	50%	30%	20%	2.98	7.85	2.71	13.54	22%	58%	20%
18	James River Cogeneration Company	Hopewell	EGU	12.65	7.59	5.06	25.30	50%	30%	20%							
19	Celanese/Cinergy Solutions (21418)	Giles	non-EGU	9.20	5.52	3.68	18.40	50%	30%	20%	0.12	0.07	0.05	0.23	50%	30%	20%
20	Dominion - Clover Power Station	Halifax	EGU	8.34	5.00	3.34	16.68	50%	30%	20%	7.34	4.01	0.81	12.17	60%	33%	7%
21	Giant Yorktown Refinery	York	non-EGU	12.74	1.59	1.59	15.93	80%	10%	10%	10.56	1.32	1.32	13.20	50%	30%	20%
22	SPSA Refuse Derived Fuel Plant	Portsmouth	non-EGU	3.43	9.05	3.12	15.61	22%	58%	20%	3.35	8.83	3.04	15.22	22%	58%	20%
23	H L Mooney Water Reclamation Facility	Prince William	non-EGU	3.21	8.47	2.92	14.61	22%	58%	20%							
24	Hopewell WWTP	Hopewell	non-EGU	2.93	7.71	2.66	13.30	22%	58%	20%							
25	HRSD Chesapeake-Elizabeth Sewage	Virginia Beach	non-EGU	2.87	7.56	2.61	13.04	22%	58%	20%							
26	Cogentrix Virginia Leasing Corp	Portsmouth	EGU	5.85	3.51	2.34	11.70	50%	30%	20%							
27	Chemical Lime Company	Giles	non-EGU	9.20	1.15	1.15	11.50	80%	10%	10%	3.92	0.49	0.49	4.90	80%	10%	10%
28	Burlington Industries LLC Hurt Fin	Pittsylvania	non-EGU	5.53	3.32	2.21	11.05	50%	30%	20%							
29	HRSD Boat Harbor Sewage Treatment Plt	Newport News	non-EGU	2.11	5.56	1.92	9.59	22%	58%	20%							
30	Roanoke Cement Company	Botetourt	non-EGU	6.96	1.21	1.11	9.28	75%	13%	12%	4.73	0.82	0.76	6.30	75%	13%	12%
31	Alliant Ammunition & Powder Co.	Montgomery	non-EGU	4.57	2.74	1.83	9.14	50%	30%	20%	0.05	0.02	0.02	0.08	58%	20%	22%
32	Philip Morris USA Inc - Park 500	Chesterfield	non-EGU	4.35	2.61	1.74	8.69	50%	30%	20%							
33	Georgia Pacific Corp Big Island Plt	Bedford	non-EGU	3.84	2.30	1.53	7.67	50%	30%	20%							
34	Mohawk Industries Inc-Lees Carpet	Rockbridge	non-EGU	3.76	2.26	1.50	7.52	50%	30%	20%							

	Facility Name	County	Source Type	Updated VDEQ Inventory							EPA 2002 NEI Version 3 Inventory						
				2002 Emissions				Speciation			2002 Emissions				Speciation		
				HG0 (lb/yr)	HG2 (lb/yr)	HGP (lb/yr)	Total (lb/yr)	HG0	HG2	HGP	HG0 (lb/yr)	HG2 (lb/yr)	HGP (lb/yr)	Total (lb/yr)	HG0	HG2	HGP
35	HRSD Virginia Initiative Plant	Norfolk	non-EGU	1.45	3.81	1.31	6.57	22%	58%	20%							
36	HRSD Army Base Sewage Treatment Plt	Norfolk	non-EGU	1.41	3.71	1.28	6.40	22%	58%	20%							
37	Intermet Corporation Radford	Radford	non-EGU	4.90	0.61	0.61	6.12	80%	10%	10%	0.18	0.02	0.02	0.23	80%	10%	10%
38	Bear Island Paper Company LLC	Hanover	non-EGU	2.96	1.77	1.18	5.91	50%	30%	20%							
39	US Navy Little Creek Amphibious Base	Virginia Beach	non-EGU	2.93	1.76	1.17	5.87	50%	30%	20%							
40	HRSD Williamsburg	James City	non-EGU	0.99	2.62	0.90	4.51	22%	58%	20%							
41	Georgia-Pacific/Emporia Plywood	Greensville	non-EGU	2.06	1.24	0.82	4.12	50%	30%	20%	2.06	1.24	0.82	4.12	50%	30%	20%
42	Covanta Alexandria/Arlington, Inc.	Alexandria	EGU	1.96	1.17	0.78	3.92	50%	30%	20%	1.41	3.72	1.28	6.41	22%	58%	20%
43	Dan River Incorporated Schoolfield	Danville	non-EGU	1.86	1.11	0.74	3.71	50%	30%	20%	0.00	0.00	0.00	0.00	80%	10%	10%
44	International Paper Company	Isle Of Wight	non-EGU	1.82	1.09	0.73	3.63	50%	30%	20%							
45	Honeywell Nylon LLC - Hopewell	Hopewell	non-EGU	1.81	1.09	0.72	3.62	50%	30%	20%	0.53	0.32	0.21	1.06	50%	30%	20%
46	Birchwood Power Partners, L.P.	King George	EGU	1.41	2.05	0.13	3.59	39%	57%	4%	2.16	1.17	0.24	3.56	61%	33%	7%
47	Solite LLC/Giant Resource Recovery	Buckingham	non-EGU	1.45	0.50	0.55	2.50	58%	20%	22%	55.73	19.22	21.14	96.08	58%	20%	22%
48	University of Virginia	Charlottesville	non-EGU	1.25	0.75	0.50	2.49	50%	30%	20%							
49	Philip Morris USA Mfg Center	Richmond	non-EGU	1.24	0.74	0.50	2.48	50%	30%	20%	1.31	0.79	0.53	2.63	50%	30%	20%
50	Dominion-Southampton Power Station	Southampton	EGU	1.10	0.66	0.44	2.19	50%	30%	20%	0.94	0.29	0.31	1.54	61%	19%	20%
51	Dominion - Altavista Power Station	Campbell	EGU	1.09	0.65	0.44	2.18	50%	30%	20%	0.89	0.26	0.29	1.44	62%	18%	20%
52	O-N Minerals (Chemstone) Strasburg	Shenandoah	non-EGU	1.74	0.22	0.22	2.17	80%	10%	10%	1.76	0.22	0.22	2.20	80%	10%	10%
53	Rock Tenn Co Mill	Lynchburg	non-EGU	0.94	0.56	0.37	1.87	50%	30%	20%							
54	Virginia Tech	Montgomery	non-EGU	0.75	0.45	0.30	1.49	50%	30%	20%							
55	Martinsville Thermal, LLC	Henry	non-EGU	0.71	0.42	0.28	1.41	50%	30%	20%	0.13	0.08	0.05	0.25	50%	30%	20%
56	Commonwealth Chesapeake Power	Accomack	EGU	0.67	0.40	0.27	1.34	50%	30%	20%							
57	Dominion - Mecklenburg Power Station	Mecklenburg	EGU	0.84	0.25	0.03	1.11	75%	22%	2%	0.34	0.25	0.07	0.65	52%	38%	10%
58	Hopewell Cogenertion Ltd Partnership	Hopewell	non-EGU	0.53	0.32	0.21	1.05	50%	30%	20%	0.30	0.18	0.12	0.60	50%	30%	20%
59	INVISTA S.a.r.l. -Waynesboro	Waynesboro	non-EGU	0.52	0.31	0.21	1.04	50%	30%	20%							
60	Dominion - Gordonsville Power Station	Louisa	EGU	0.41	0.25	0.16	0.82	50%	30%	20%							
61	Griffin Pipe Products Company	Lynchburg	non-EGU	0.57	0.07	0.07	0.71	80%	10%	10%							
62	O-N Minerals (Chemstone) Clearbrook	Frederick	non-EGU	0.32	0.04	0.04	0.40	80%	10%	10%	0.32	0.04	0.04	0.40	80%	10%	10%
63	Hampton/NASA Steam Plant	Hampton	non-EGU	0.07	0.17	0.06	0.30	22%	58%	20%	64.92	171.16	59.02	295.11	22%	58%	20%
64	Perdue Farms - Soybean Oil Processing	Chesapeake	non-EGU	0.13	0.08	0.05	0.26	50%	30%	20%	0.98	0.59	0.39	1.95	50%	30%	20%
65	Philip Morris USA Inc. - Leaf Processing	Richmond	non-EGU	0.10	0.06	0.04	0.20	50%	30%	20%	0.03	0.02	0.01	0.07	50%	30%	20%
66	Mead Westvaco Virginia Specialty	Covington	non-EGU	0.07	0.01	0.01	0.09	80%	10%	10%							
67	Blacksburg Sanitation Authority	Montgomery	non-EGU	0.01	0.03	0.01	0.06	22%	58%	20%							
68	Philip Morris USA Inc. - Blended Leaf	Richmond	non-EGU	0.03	0.02	0.01	0.05	50%	30%	20%	2.25	1.35	0.90	4.51	50%	30%	20%

Figure 2-1 presents a comparison of total emissions for the 68 Virginia mercury point sources with emissions from those same sources contained in the NEI. A comparison of totals shows the NEI inventory with 12 percent higher emissions. As noted above, this is due to the fact that a few large emitters listed in the NEI have been closed in recent years or that this version of the NEI contains outdated and/or erroneous emission estimates for certain sources. For example, source #63 in Table 2-2 shows a total of 0.3 lbs/yr total mercury emissions in the updated Virginia inventory and 295 lbs/yr total mercury in the NEI inventory, which is obviously wrong based on the updated survey information.

For the mercury deposition modeling analysis, the updated Virginia point source inventory will be combined with emissions from point and non-point sources contained in the NEI. The emissions for the 68 facilities will be combined with emissions from other Virginia sources contained in the NEI inventory, but not included in the list of 68. The emissions for these other NEI sources were also reviewed by VDEQ as part of this work, and some of these sources were eliminated because they were either closed or were not regarded as "air" sources by VDEQ. Although the emissions from the remaining valid NEI sources are very small, they will be accounted for in the deposition modeling analysis. As noted above, it is expected that emissions for Virginia's updated mercury point source inventory will be submitted to EPA, along with changes/corrections/shutdowns to any other Virginia source in the existing NEI, for inclusion in the next version of the NEI.

Figure 2-1. Mercury Emissions for Virginia Point Sources: 2002 VDEQ vs. 2002 NEI V3

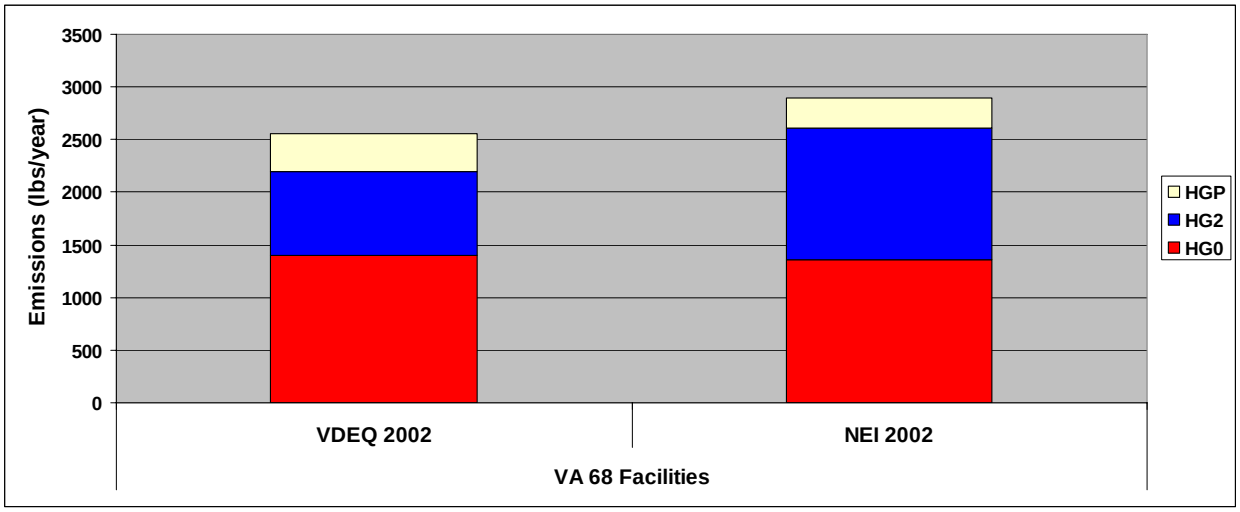
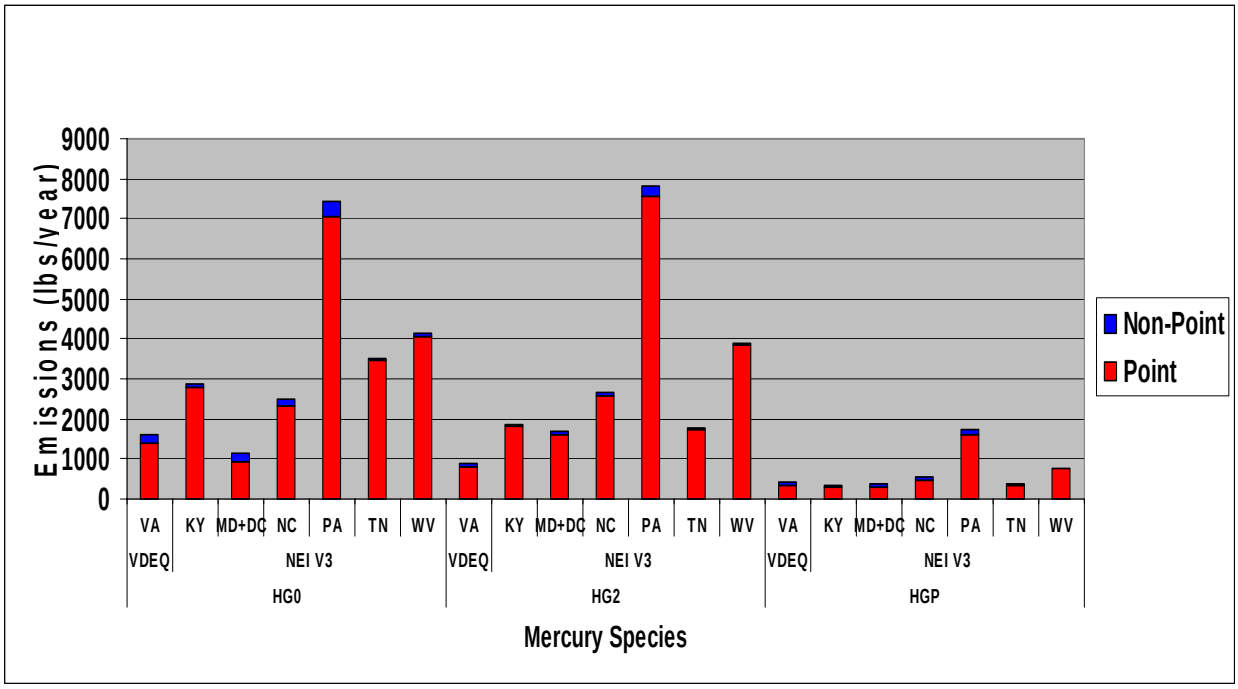


Figure 2-2 presents a comparison of the 2002 Virginia mercury emissions with those contained in the NEI for the neighboring states of Kentucky, Maryland/D.C., North Carolina, Pennsylvania, Tennessee, and West Virginia. These emissions and emissions from all other states in the modeling domain obtained from the NEI inventory will be used in the mercury air deposition modeling. Of the seven states, Virginia's emissions are comparable to the combined Maryland/D.C. emissions totals. The neighboring states have the potential to influence mercury deposition in Virginia watersheds and emissions from these states will be fully accounted for in the modeling analysis.

Figure 2-2. Comparison of the 2002 VDEQ Speciated Mercury Emissions Inventory with the 2002 NEI Version 3 Inventory for Selected Neighboring States

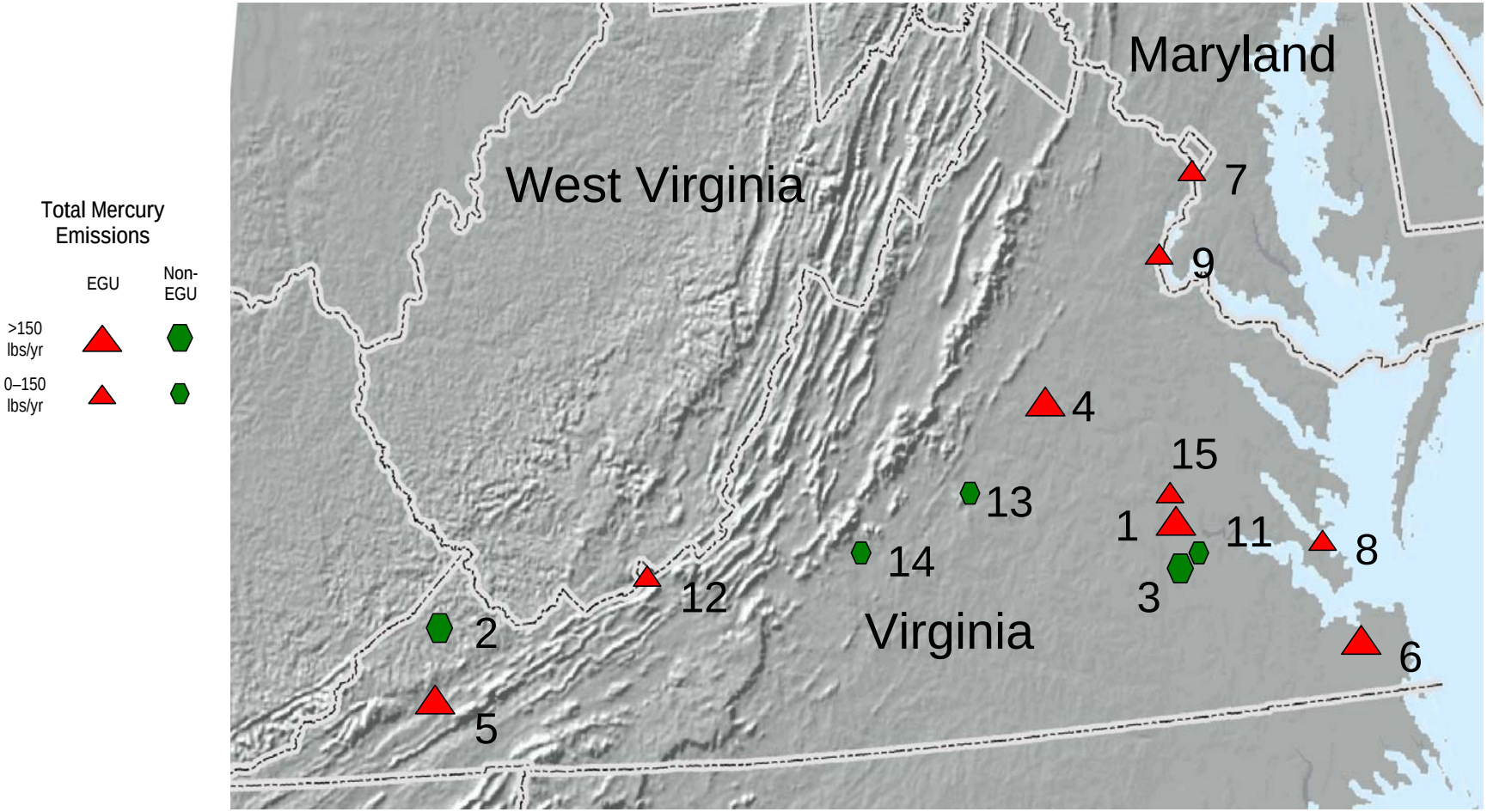


3. Summary of Virginia Mercury Inventory

3.1. Base-Year Emission Inventory for Modeling

The 2002 Virginia mercury point source inventory, as listed in Table 2-1, will be processed and used with the CMAQ air quality modeling system to estimate mercury deposition affecting Virginia waterways. To provide an example of the point-source emissions as they will be input to the model, Figure 3-1 presents the location and magnitude of the top 15 mercury point sources in Virginia for 2002 as contained in Table 2-1. These 15 EGU and non-EGU point sources represent 86 percent of total mercury point source emissions for Virginia in 2002. The figure presents information for total annual mercury emissions from these sources in two ranges: 0 – 150 lbs/yr and > 150 lbs/yr.

Figure 3-1. Location and Magnitude of the Top 15 Virginia Mercury EGU and Non-EGU Point Sources for 2002 (Hg-Total Mercury)



	Facility Name	County	Source Type		Facility Name	County	Source Type
1	Dominion–Chesterfield Power Station	Chesterfield	EGU	9	Dominion-Possum Point Power Station	Prince William	EGU
2	Jewel Coke Company LLP	Buchanan	non-EGU	10	Stone Container Enterprises (Smurfit)	King William	non-EGU
3	Chaparral Steel	Dinwiddie	non-EGU	11	Stone Container Corporation -Hopewell	Hopewell	non-EGU
4	Dominion–Bremo	Fluvanna	EGU	12	American Electric Power	Giles	EGU
5	American Electric Power- Clinch River	Russell	EGU	13	Intermet Foundry Archer Creek	Campbell	non-EGU
6	Dominion–Chesapeake Energy Center	Chesapeake	EGU	14	RES dba Steel Dynamics	Roanoke	non-EGU
7	Potomac River Generating Station	Alexandria	EGU	15	Spruance Genco LLC	Richmond	EGU
8	Dominion–Yorktown Power Station	York	EGU				

3.2. Future-Year Emission Inventory Estimates for Virginia Sources

For this study, mercury air deposition will be assessed in the modeling analysis for 2002 and three future years: 2010, 2015, and 2018. As noted above, recent national control legislation promulgated by EPA in the Clean Air Interstate Rule (CAIR) will reduce emissions of NO_x, SO_2, and mercury from coal-fired power plants in the eastern US. Phase 1 controls for NOx are due in place by January 2009, while phase 1 controls for SO_2 are due by January 2010. Phase 2 controls for NO_x and SO_2 are both due by January 2015. Mercury emissions reduction benefits will be realized from the NO_x and SO_2 controls in place by January 2010. The Clean Air Mercury Rule (CAMR) will build on CAIR and provide for additional future mercury emission reductions from these sources. Mercury controls are mandated to be in place by January 2018 for those coal-fired power plants subject to the rule.

Presently, a number of Virginia sources have existing pollution control equipment installed and running, while others are planning on installing future controls. Table 3-1 presents a summary of control equipment currently being utilized or planned to be installed by Virginia coal-fired boilers. Most of the new control equipment is expected to be installed by 2010.

Table 3-1. Summary of Existing and Planned Emission Controls for Virginia Coal Fired Boilers

Facility Name	MW (NOx SIP Call)	MW Calculated	Control Equipment[1]	Projected Control Equipment	Projected Year To Install
Dominion - Chesterfield Power Station (1)					
3	113	110.0	OFA/LNB/ESP	FGD	2011
4	188	167.7	SCR/ESP/Staged combustion	FGD	2011
5	359	343.2	SCR/ESP/Staged combustion	FGD	2011
6	694	633.3	SCR/ESP/Staged combustion	FGD/FF	2008
Dominion - Bremo Power Station (4)					
3	69	86.9	ESP (hot sided)/BOOS		
4	185	161.8	ROFA/ESP (hot sided)		
American Electric Power - Clinch River (5)					
1	235	200.0	staged combustion/ESP		
2	235	200.0	staged combustion/ESP		
3	235	200.0	staged combustion/ESP		
Dominion - Chesapeake Energy Center[2] (6)					
1	113	123.8	OFA /ROFA/ESP	SA Coal 50% CE for Hg and 40% for S	2007
2	113	123.8	OFA/ROFA/ESP	SA Coal 50% CE for Hg and 40% for S	2007
3	185	158.4	LNB/SCR/ESP	SA Coal 50% CE for Hg and 40% for S	2007
4	239	223.4	LNB/SCR/ESP (all cold sided)	SA Coal 50% CE for Hg and 40% for S	2007
Potomac River Power Generating Station[3] (7)					
1	93	92.4	LNB/ESP		
2	93	92.4	LNB/ESP		
3	108	91.5	LNB/SOFA/ESP		
4	108	91.5	LNB/SOFA/ESP		
5	108	91.5	LNB/SOFA/ESP		
Dominion - Yorktown Power Station (8)					
1	188	161.6	LNB/OFA/SNCR/ESP	FGD	2015
2	188	166.2	LNB/OFA/SNCR/ESP	FGD	2015
Stone Container Corp., West Point Mill[4](10)					
2			Concentric firing/LNB/ESP	SO2 Scrubber	2008
Stone Container Corp., Hopewell (11)					
1		80.6	ESP		
American Electric Power - Glen Lyn (12)					
51	100	54.5	staged combustion/ESP		
52	100	54.5	staged combustion/ESP		
6	238	194.3	staged combustion/ESP		
Spruance Genco LLC (15)					
BLR01A		35.7	SNCR/FGR/OFA/Meth/FF/D FGD		
BLR01B	115	35.7	SNCR/FGR/OFA/Meth/FF/D FGD		
BLR02A		35.7	SNCR/FGR/OFA/Meth/FF/D FGD		
BLR02B	115	35.7	SNCR/FGR/OFA/Meth/FF/D FGD		
BLR03A		35.7	SNCR/FGR/OFA/Meth/FF/D FGD		
BLR03B	115	35.7	SNCR/FGR/OFA/Meth/FF/D FGD		
BLR04A		35.7	SNCR/FGR/OFA/Meth/FF/D FGD		
BLR04B	115	35.7	SNCR/FGR/OFA/Meth/FF/D FGD		
James River Cogeneration (18)					
BLR01A		19.0	FGR/OFA/FF	SDA	2010
BLR01B		19.0	FGR/OFA/FF	SDA	2010
BLR01C	108.5	19.0	FGR/OFA/FF	SDA	2010
BLR02A		19.0	FGR/OFA/FF	SDA	2010
BLR02B		19.0	FGR/OFA/FF	SDA	2010
BLR02C	108.5	19.0	FGR/OFA/FF	SDA	2010
Dominion - Clover Power Station (20)					
1	424	389.0	LNB/SNCR/FF/Wet FGD		
2	424	389.0	LNB/SNCR/FF/Wet FGD		

Summary of Virginia Mercury Inventory

Facility Name		MW (NOx SIP Call)	MW Calculated	Control Equipment[1]	Projected Control Equipment	Projected Year To Install
Cogentrix Virginia Leasing-Portsmouth (26)						
	BLR01A		19.0	FGR/OFA/FF	SDA	2010
	BLR01B		19.0	FGR/OFA/FF	SDA	2010
	BLR01C	108.5	19.0	FGR/OFA/FF	SDA	2010
	BLR02A		19.0	FGR/OFA/FF	SDA	2010
	BLR02B		19.0	FGR/OFA/FF	SDA	2010
	BLR02C	108.5	19.0	FGR/OFA/FF	SDA	2010
Georgia-Pacific - Big Island Plant (33)						
	4		27.0	ESP		
	6		27.1	LNB/FGR (not coal fired)		
Dan River Inc—Schoolfield Complex (43)						
			24.0	ESP		
International Paper Co. - Franklin Mill (44)						
	3		47.2	ESP		
	17			shutdown		
	29			LNB/SCR		
Birchwood Power Partners Facility (46)						
	1	240	219.0	SCR/FF/DLS		
Dominion - Southampton Power Station (50)						
	1	71.1	38.1	OFA/DFGD/FF/Staged combustion		
62.7 MW total	2	71.1	38.1	OFA/DFGD/FF/Staged combustion		
Dominion - Altavista Power Station (51)						
	1	71.1	36.4	SNCR/LNB/DLS/FF		
	2	71.1	36.4	SNCR/LNB/DLS/FF		
Dominion - Mecklenburg Cogeneration Facility (57)						
	1		79.4	LNB/OFA/FF/FGD		
	2	139.9	79.4	LNB/OFA/FF/FGD		
Mead Westvaco Virginia Specialty, Covington (66)						
	1		52.4	LNB/ESP/FGD		
	2		41.9	FGR /ESP/FGD		
	3		55.2	FGR/ESP/FGD		
	4		76.9	LNB/ESP/FGD		
	5					
	11			LNB/FGR		

[1] Control equipment includes the following: selective catalytic reduction (SCR), selective non-catalytic reduction (SNCR), low-NOx burners (LNB), electrostatic precipitators (ESP), dry lime scrubbing (DLS), fabric filters (FF), over-fired air (OFA), flue-gas desulfurization (FGD), flue-gas recirculation (FGR), rotating opposed-fired air (ROFA), and burners out of service (BOOS).

[2] Chesapeake Energy Center was originally slated to be controlled by SDA. However, a Dominion update of the control plan notes these installations are indefinitely delayed, and South American coal with about half of the Hg content and about 40% lower sulfur content is currently being used at the facility.

[3] Potomac River is currently using Trona injection on 3, 4, and 5. They are also subject to the CAIR cap without trading provisions due to their location in a nonattainment area. They will be capped for both NOx and SO2.

[4] Installation of the SO2 scrubber by 2008 is the result of a federal consent decree and enforcement action.

For those EGU sources subject to EPA's CAMR reductions, future year emissions budgets have been established based on the CAMR provisions as well as Virginia-specific emissions rules. According to VDEQ, proposed mercury allowance allocations to coal fired electric steam generating units in Virginia, for the control period 2010 – 2017, were made according to State Air Pollution Control Board Regulation for Emission Trading Programs. A total of 95 percent of the allocated state budget of 1184 lbs (0.592 tons, excluding 4% set-aside for the new and 1%

for energy efficient units) are distributed to the existing units in proportion to their baseline heat input in million Btu. The baseline heat input for this purpose is the average of three highest amounts of the unit's control period heat input for the years 2000 through 2004.

Table 3-2 presents the estimated future-year budgets for those Virginia EGU's subject to CAMR for 2014, 2015-17, and 2018. The number in the table corresponds to the number in the 2002 inventory table (Table 2-2) above. Because many of the EGU sources listed have (or will have) controls in place to reduce mercury emissions below these budgets, the actual future year emissions to be used in the mercury deposition modeling analysis may be different than those listed in the table.

Table 3-2. Future Year Mercury Emissions Budgets for Virginia EGU's Subject to CAMR

#	Facility Name	County	Source Type	2002				2014	2015–2017	2018
				HG0 (lb/yr)	HG2 (lb/yr)	HGP (lb/yr)	Total (lb/yr)	Total (lb/yr)	Total (lb/yr)	Total (lb/yr)
1	Dominion - Chesterfield Power Station	Chesterfield	EGU	179.42	107.65	71.77	358.83	230.39	94.00	94.00
4	Dominion – Bremo Power Station	Fluvanna	EGU	83.86	50.32	33.55	167.73	44.45	18.14	18.14
5	American Electric Power- Clinch River	Russell	EGU	38.21	121.00	0.00	159.21	113.40	113.40	46.27
6	Dominion - Chesapeake Energy Center	Chesapeake	EGU	78.69	47.22	31.48	157.38	122.04	49.79	49.79
7	Potomac River Generating Station	Alexandria	EGU	11.83	106.43	0.00	118.26	72.96	72.96	29.77
8	Dominion - Yorktown Power Station	York	EGU	53.82	32.29	21.53	107.64	58.08	23.70	23.70
9	Dominion-Possum Point Power Station	Prince William	EGU	50.09	30.06	20.04	100.19	56.93	23.23	23.23
12	American Electric Power – Glen Lyn	Giles	EGU	26.06	39.08	0.00	65.14	47.69	47.69	19.46
15	Spruance Genco LLC	Richmond	EGU	27.75	16.65	11.10	55.50	55.50	55.50	22.64
18	James River Cogeneration Company	Hopewell	EGU	12.65	7.59	5.06	25.30	24.54	24.54	10.01
20	Dominion - Clover Power Station	Halifax	EGU	8.34	5.00	3.34	16.68	190.08	77.55	77.55
26	Cogentrix Virginia Leasing Corp	Portsmouth	EGU	5.85	3.51	2.34	11.70	19.19	19.19	7.83
46	Birchwood Power Partners, L.P.	King George	EGU	1.41	2.05	0.13	3.59	38.57	38.57	15.74
51	Dominion - Altavista Power Station	Campbell	EGU	1.09	0.65	0.44	2.18	11.07	4.52	4.52
57	Dominion - Mecklenburg Power Station	Mecklenburg	EGU	0.84	0.25	0.03	1.11	25.74	15.56	10.50

4. Summary of Recent Mercury Studies

This section summarizes information that may be relevant to the current study from recent papers and presentations on data collection and analysis, modeling, and emissions and controls studies of mercury deposition. Note that all of the references given in this section can be found in the bibliography provided in the appendix. They are also available on the Virginia DEQ Mercury Study web page: http://www.deq.virginia.gov/air/vamercury/vamercurystudy.html

4.1. General Mercury Deposition and Data Analysis Studies

Numerous reports and papers discuss the state-of-the science of mercury deposition, with emphasis on the sources of airborne mercury, mercury chemistry, global and regional transport, mercury deposition mechanisms, and mercury effects on aquatic ecosystems. Several studies focus on the analysis of collected mercury deposition data for specific locations. A few recent studies examine the relationships between meteorology and mercury deposition.

General Studies

Nearly all of the papers and reports examined discussed the **sources of mercury** in the atmosphere. It is widely understood that mercury is emitted to the atmosphere from both natural and anthropogenic sources.

Certain soils, rocks, and other geologic structures naturally contain mercury and therefore represent natural or geogenic sources of mercury emissions. Volcanic activity is thought to be an important but variable source of naturally occurring airborne mercury (Niagru and Becker, 2003). Within North America, most natural mercury emissions are associated with land types found in the western part of the continent. In addition to the land masses, the oceans are also a source of natural mercury emissions. Emissions fluxes from the ocean are thought to be greatest near the equator and to decrease toward the poles (Seigneur et al., 2003; Kim and Fitzgerald, 1986).

Anthropogenic sources of mercury include coal-fired power plants and other industrial coal-burning facilities, municipal, medical, industrial and hazardous waste incinerators, chlor-alkali and other chemical manufacturing plants, taconite and other metallurgical processing facilities, pulp and paper manufacturing facilities, mining operations, cement plants, mobile sources, and a wide variety of other industrial and residential sources (EPA, 2005).

It is also widely understood that re-emission of both natural and anthropogenic emissions from both land and water areas is an important part of the global mercury budget. Over land, prescribed burning and wild fires can increase the rate of re-emission.

Driscoll et al. (2007) estimates that approximately one-third of the emissions are direct anthropogenic emissions. Valente et al. (2007) summarizes the results of numerous studies in estimating that global mercury emissions are equally apportioned among natural emissions, direct anthropogenic emissions, and re-emission of previously deposited natural and anthropogenic emissions.

Understanding the **mercury chemistry** is an active area of research. Bullock et al. (2007) summarizes the three forms of airborne mercury (Hg) as follows: elemental mercury (Hg(0)), reactive gaseous mercury (RGM), and particulate mercury (Hg(p)). RGM is known to be comprised almost entirely of divalent mercury (Hg^{2+} or Hg(II)), since mercury compounds at other valence states tend to be chemically unstable in the atmosphere. Hg(p) is also primarily comprised of divalent mercury, but may also include elemental mercury.

Valente et al. (2007) and others offer that elemental mercury is the dominant atmospheric species and comprises about 99 percent of the total mercury in the atmosphere. Hg(0) is characterized by low reactivity and low solubility in water and has a long atmospheric lifetime. RGM represents less than one percent of atmospheric mercury. It is highly reactive and highly soluble and can be actively removed from the atmosphere through both wet and dry deposition processes. Hg(p) also represents less than one percent of atmospheric mercury. It is moderately reactive and highly soluble in water. It is removed from the atmosphere primarily through wet deposition

Seigneur et al. (2003) discuss the chemical transformations that transfer mercury mass from one of these states to another. Several gas phase and aqueous phase reactions and equilibrium processes are expected to be important.

The **global and regional transport** of mercury is the topic of much discussion in the current literature, especially in explaining deposition observed at remote locations and in the context of mercury deposition modeling. With an atmospheric lifetime that may be on the order of months to years, Hg(0) is dispersed and transported globally by atmospheric circulation systems and regionally by large-scale weather systems. Similarly, with atmospheric lifetimes on the order of a week, RGM and Hg(p) may also be subject to regional-scale transport.

With regard to **deposition mechanisms**, a key area of interest is the re-emission of mercury from both land and water surfaces (e.g., Sofiev and Galperin (2000)). Prescribed burning and wild fires may account for some of the re-emissions. Other natural processes, including microbial activity, may also account for some of the re-emission (Syrakov, 1998). Re-emission of mercury is mainly in the form of Hg(0) (Schluter, 2000).

Of primary interest for states and EPA is the **impact of mercury deposition on aquatic ecosystems**. In the U.S., more than 8,500 individual bodies of water have been identified as mercury impaired and the primary source of mercury to these water bodies is believed to be atmospheric deposition. For example, the South Florida Mercury Science Program found that atmospheric deposition of mercury accounts for more than 95 percent of the new mercury entering the Everglades each year (Fink et al., 1998).

Based on the network of mercury deposition measurements for the Northeast, Driscoll et al. (2007) concludes that mercury can be directly deposited onto surface waters or deposited in forest and wetland areas and then transported through the watershed to accumulate in the surface waters.

In certain bodies of water such as those with low dissolved oxygen, high organic matter content, and low acidity, mercury deposition can lead to the formation and build up of the highly bio-accumulative form of mercury (methyl mercury, CH_3Hg^+ or $MeHg^+$). Human exposure to mercury is linked with the consumption of contaminated fish from such water bodies.

Analysis of Mercury Deposition Data for Specific Locations

Numerous analyses of mercury deposition data (e.g., Seigneur et al. (2003) indicate that there are spatial patterns in the data and that these can vary from year to year. While the patterns are clearly related to rainfall amount, some studies (for example, Keeler et al. (2006)) suggest that there are spatial patterns in the wet deposition data that are not fully accounted for by the rainfall patterns. This suggests the potential for impact from local and regional sources.

An analysis of wet mercury deposition for two rural, coastal sites in North Carolina (Haywood et al., 2000 and others) revealed both a spatial pattern as well as a seasonal pattern of wet

mercury deposition when the data are separated into summer (April – September) and winter (October–March) months.

While most monitoring of mercury is of wet deposition, several studies have also examined mercury air concentrations and dry deposition.

Haywood et al. (2000) also found that both mercury concentration and wet deposition rates are consistently higher at Lake Waccamaw than Pettigrew State Park (both located in coastal North Carolina) and surmised that the pattern could be a result of local source influences.

The National Oceanic and Atmospheric Administration (NOAA) Air Resources Laboratory (NOAA, 2007) conducted a monitoring study during the summer of 2005 at the Harcum site in coastal Virginia which revealed that dry deposition was significant and was dominated by RGM.

Relationships between Meteorology and Mercury Deposition

It is recognized that in addition to the location of sources and the chemical species of mercury emitted, climate and meteorology are key factors in mercury deposition. The relationship between precipitation and deposition is well established. Scavenging by wet deposition is an important mechanism for wet deposition. Few studies, however, address the potentially more complex relationships between meteorology and mercury deposition. EPA (1997) reported that, in general, humid locations have higher deposition rates than arid locations. Keeler et al. (2006) found the annual amount of precipitation to be related to annual mercury deposition. They also found that individual precipitation events can contribute significantly to the annual mercury deposition totals.

4.2. Mercury Air Modeling Studies

Current literature focuses on the development of mercury capabilities in air quality modeling and some national- and regional-scale applications.

Bullock and Brehme (2006) present a description of the methodology for modeling mercury using CMAQ Version 4.5.1. This paper provides a description of the mercury treatment in the CMAQ model that will be used in this study (although the version that will be used for this study is 4.6, the mercury treatment is effectively unchanged). Note that the Particle and Precursor Tagging Methodology (PPTM) has been added to version 4.6.

Several areas of potential uncertainty that may be useful in designing and conducting sensitivity analysis with CMAQ are pointed out in this paper. These include:

- Rates of chemical reactions.
- Deposition of elemental mercury.
- Natural emission and re-emission of mercury.

The presentation of Vijayaraghavan et al. (2005) provides a potential reference/comparison for model performance for the VDEQ study. The authors add the following to the list of potential sources of uncertainty for CMAQ:

- Global emissions.
- Input meteorology, specifically rainfall.
- Dispersion of plumes.

- Chemistry in plumes.

The authors also suggest that the lifetime of mercury in the atmosphere as 1.2 years.

Lin et al. (2004) suggest that the lifetime of mercury in the atmosphere is 0.5 to 2 years and also present some potential implementation issues regarding simulation of mercury with CMAQ. These include:

- Specific uncertainties in gas phase chemistry and in deposition
- Potential for much more rapid oxidation of Hg(0) by halogens in coastal areas

Areas of potential improvement in CMAQ are presented by Lin et al. (2005). Of interest here is the sensitivity to possible improvements in CMAQ algorithms. Some of these improvements have been addressed in Version 4.6 of CMAQ. These include natural emissions and dry deposition of elemental mercury. Additional improvements noted by Lin et al. may be considered during the selection of sensitivity simulations.

Pongprueksa and Lin (2006) conducted sensitivity simulations for mercury using CMAQ. They specifically explored the sensitivity of the simulation results to additional Hg(II) reduction reactions.

Several related papers present information on natural emissions and sensitivity to the CMAQ system to changes in emissions (Wen, 2006; Gbor et al., 2006; Gbor et al., 2004). Topics addressed in these papers include:

- A methodology for estimating natural emissions.
- Deposition vs. evasion of Hg.
- Sensitivity of simulation results to changes in emissions of Hg, NOx, VOC, etc.

To the extent possible, we may qualitatively compare the results of these sensitivity tests to the VDEQ modeling results.

A comparison of model-based and observation-based estimates of dry deposition is made in Marsik et al. (2007). The authors compare the direct measurement of dry deposition to estimates from a resistance model, such as that employed by CMAQ. This gives us some insight into the quality of the CMAQ dry deposition estimates.

A presentation by Braverman (2005) provides some information on EPA's regulatory modeling related to mercury. This presentation gives some background on the Clean Air Mercury Rule (CAMR) modeling and a summary of CMAQ model performance in CAMR. Again, this provides a potential source of comparison for model performance for the VDEQ study.

Discussions of plume models vs. grid model treatments for mercury are discussed in Karamchandani et al. (2006) and Seigneur et al. (2006). The authors present some expected benefits of a plume-in-grid treatment for point sources, with an emphasis on power plant plumes. Comparisons of Hg deposition estimates from grid models and a Gaussian model are provided. Of interest for the VDEQ modeling study is a description of a methodology for estimating deposition using a Gaussian model.

Regional modeling with the SARMAP Air Quality Model (SAQM) studies mercury concentrations in Connecticut (Xu et al., 2000a; Xu et al., 2000b). This study is limited to a small section of the

northeastern U.S. around Connecticut and uses the SAQM model with simple and probably outdated Hg chemistry. The authors include estimates of natural emissions and re-emissions, which may be of some interest for the VDEQ study.

A project update by Walcek (2005) provides information on a modeling study in New York State. It is possible that the estimates of in-state vs. out-of-state contributions to deposition in New York from this study could provide a check on the estimates obtained from the VDEQ study.

A brief project update by Seigneur (2005) summarizes estimates of global and regional contributions to mercury deposition in New York State. This work includes a modeling sensitivity analysis and estimates of deposition contributions to New York State for various emissions sectors. A key finding is that the greatest contributor is U.S. emissions sources (non-New York emissions).

Several reports present the results of national- and regional-scale mercury deposition modeling conducted for the EPA Office of Water (OW), as well as background on and results from the Particle and Precursor Tagging Methodology (PPTM). Modeling of mercury deposition in Wisconsin is reported by Myers et al. (2006a). This report was intended as a peer-reviewed prototype for mercury tagging using the REMSAD model and includes:

- PPTM results for Wisconsin sources with deposition estimates for mercury.
- An estimate of potential year-to-year variability in Hg deposition for several sites in Wisconsin.

Similar modeling in support of the Maryland TMDL is reported by Myers et al. (2004a). This study included:

- Hg tagging simulations using REMSAD for Maryland and surroundings to estimate deposition of Hg.
- An estimate of potential year-to-year variability in Hg deposition for several sites in Maryland.

Additional modeling in support of a Louisiana TMDL is reported by Myers et al. (2004b). This study included:

- Hg tagging simulations for Louisiana and surroundings using REMSAD.
- Estimates of mercury deposition loading from tagged Louisiana sources for Louisiana estuaries.

Simulation results for the entire U.S. are reported by Myers et al. (2006b). In this study, PPTM was applied for approximately 300 sources located throughout the U.S. The study results include estimates of mercury deposition contributions for some Virginia sources. These results may provide a check on similar estimates obtained from the VDEQ study.

Attribution of global emissions to mercury deposition is treated by Seigneur et al. (2004). This paper provides

- Global simulation results using the Chemical Transport Model (CTM).
- Estimates of contributions of various regions of the world to deposition in U.S.

The potential influence of Asian mercury emissions on the U.S. is examined by Lin et al. (2006). Direct deposition of Asian emissions to Virginia should be small, but their contribution to global background may be important.

As an alternative to grid-based modeling, use of the HYSPLIT model is discussed in Cohen et al. (2004) and in Cohen (2004). The authors estimate contributors to mercury deposition to Great Lakes and the Chesapeake Bay using HYSPLIT model. The results tend to differ from other modeling estimates in that very distant sources may contribute to deposition loading. The use of trajectory modeling over long periods of time adds considerable uncertainty to the HYSLPIT modeling approach.

A combination of statistical and modeling techniques is used by Michaels et al. to examine the possible link between local power plant emissions and impaired bodies of water in Virginia. This study relied on HYSPLIT trajectory modeling of Virginia power plants. The authors were not able to establish a statistical link between elevated Hg in fish tissue with power plant emissions.

4.3. Mercury Emissions and Control Studies

As noted above, mercury in the atmosphere originates from a wide variety of anthropogenic, biogenic, and geogenic sources. As mercury deposition and contamination issues have become more important in many areas of the country in the last decade, efforts have been made to prepare more accurate estimates of emissions from mercury sources. Like the criteria pollutant inventories maintained by each state, the mercury emissions inventories are used by EPA and states to assess long term trends in emissions and for rule compliance. In addition, these inventories are used in air quality modeling studies to assess deposition for a base year and as a means of evaluating changes in mercury deposition in a future year. As part of its ongoing development work with the CMAQ modeling system, EPA has developed a methodology to estimate mercury emissions from biogenic sources (Lin, et al., 2004). This methodology will be evaluated for potential use in the Virginia mercury modeling analysis. Other researchers have investigated mercury emissions from soils as a contributor to atmospheric loading. Schluter (2000) found that mercury evaporation rates from non-contaminated soils are small, but do contribute to overall emissions of both elemental and methyl mercury.

Controlling anthropogenic sources of mercury has been the focus of a number of studies conducted in recent years by EPA, the Department of Energy (DOE), and a number of state agencies, with research in control technology ranging from those placed on large industrial combustion sources (e.g., EGU's) to ensuring the proper recycling and disposal of fluorescent light bulbs. The DOE conducted a study evaluating the control efficiencies and effects of selective catalytic reduction (SCR) and fluidized gas desulfurization (FGD) on mercury speciation and removal (Withum, et al, 2006). The study found that the combination of the SCR with FGD removed a substantial amount of mercury from the flue gas. A similar study by Lee, et al. (2004) investigated the effects of SCR on mercury speciation using three different types of coal, and concluded that the effects of SCR in promoting elemental mercury oxidation and removal is highly dependent on the sulfur and chlorine content of the coal.

A number of state agencies have evaluated a list of potential mercury control technologies, including North Carolina (2005), Minnesota (2005), and NESCAUM (2004). The North Carolina and NESCAUM studies primarily focus on controls for EGU's and include various updates of control technology information, cost/benefit information, and recommendations for reducing emissions from such sources. The Minnesota report provides the 2005 annual summary for the Minnesota Legislature of efforts underway to meet the state standards. The report indicates that much of the reduction in mercury air emissions in Minnesota since 1990 has been the result of significant changes in "product use and disposal" category, which includes such items as the elimination of mercury as a preservative in paint products, the use of mercury in electric

switches, and the use of mercury in batteries. These studies provide good references for activities and controls other states have evaluated and undertaken to reduce mercury air emissions from a variety of source sectors.

4.4. Summary of Findings and Implications for Mercury Modeling Analysis

The tools and methods that will be applied for the Virginia mercury deposition modeling represent the current state-of-the-science in regulatory mercury deposition modeling. Similar approaches were used by EPA in the Clean Air Mercury Rule (CAMR) modeling. Ongoing research in the areas of mercury data collection and analysis, deposition modeling, and control technology assessment offers some possibilities for enhancing the VDEQ modeling effort, especially with regard to designing and conducting modeling sensitivity analyses, evaluating model performance, and assessing the effectiveness of local controls. Specific implications and action items for the VDEQ modeling study include:

- Qualitatively compare the modeled results for mercury concentration, wet deposition, and dry deposition with the findings from monitoring studies in North Carolina and Virginia (Harcum) regarding the observed spatial and temporal distributions and relationships among these parameters and with other modeling studies.
- As time and budget allow, conduct model-based sensitivity tests to examine the following key issues:
  - Sensitivity of the modeling results to meteorological inputs, and specifically precipitation amounts.
  - Uncertainties in the mercury chemistry and deposition algorithms.
  - Role of natural emissions.
- Ensure that future-year emissions controls are consistent with recent studies regarding effects on speciation of emissions and the overall effectiveness of control measures.
- To the extent possible, obtain and utilize future-year national emission inventories that reflect planned mercury control technologies/measures prepared by other states.

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http://www.ecy.wa.gov/programs/eap/pbt/mercuryplan.html

North Carolina, *North Carolina's Mercury Information Page*:
http://www.p2pays.org/mercury/general.asp#ncgen

National Energy Technology Laboratory

This list server is produced by the National Energy Technology Laboratory (NETL) to provide monthly updates on recent events, publications, presentations, and technical reports related to mercury. For further information, please visit the Environmental & Water Resource (E&WR) website at http://www.netl.doe.gov/technologies/coalpower/ewr/index.html.

The following are new mercury project reports that have been recently added to the E&WR website. Each link will take you directly to the report.

- A report, "The Economics of Powder River Basin Coalbed Methane Development," prepared by Advanced Resources International, Inc., January 2006, has been posted at http://www.netl.doe.gov/technologies/coalpower/ewr/pubs/netl%20Cost%20of%20Produced%20Water%20Treatment%200106.pdf.

- A quarterly progress report, "Field Testing of Activated Carbon Injection Options for Mercury Control at TXU's Big Brown Station," prepared by University of North Dakota Energy & Environmental Research Center for the period of October 1–December 31, 2005, has been posted at http://www.netl.doe.gov/technologies/coalpower/ewr/mercury/control-tech/pubs/JP-ACI%20at%20BB-42305-Dec05.pdf.

- A quarterly progress report, "Evaluation of MerCAP™ for Power Plant Mercury Control," prepared by URS Group, Inc. for the period of October 1–December 31, 2005, has been posted at http://www.netl.doe.gov/technologies/coalpower/ewr/mercury/control-tech/pubs/41993_Q123105.PDF.

- A quarterly progress report, "Pilot Testing of Mercury Oxidation Catalysts for Upstream of Wet FGD Systems," prepared by URS Corporation for the period of October–1 December 31, 2005, has been posted at http://www.netl.doe.gov/technologies/coalpower/ewr/mercury/control-tech/pubs/GRE-CPS123105.pdf.

- A quarterly progress report, "Pilot Testing of Mercury Oxidation Catalysts for Upstream of Wet FGD Systems," prepared by URS Corporation for the period of October 1–December 31, 2005, has been posted at http://www.netl.doe.gov/technologies/coalpower/ewr/mercury/control-tech/pubs/TXU-Duke-SCC123105.pdf.

- A final site report for testing conducted at the Laramie River Station for the project entitled "Evaluation of Sorbent Injection for Mercury Control," prepared by ADA-ES, Inc., for the period of October 1, 2003 through December 31, 2005 has been posted at http://www.netl.doe.gov/technologies/coalpower/ewr/mercury/control-tech/pubs/toprpt_laramie_river_station.pdf.

- Two quarterly progress reports for the project entitled "Field Test Program for Long-Term Operation of a COHPAC® System for Removing Mercury from Coal-Fired Flue Gas," prepared by ADA-ES, Inc., have been posted:

  1. Quarterly period of July 1–September 30, 2005: http://www.netl.doe.gov/technologies/coalpower/ewr/mercury/control-tech/pubs/41591%20Q093005.pdf.

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- Three quarterly progress reports for the project entitled "Low-Cost Options for Moderate Levels of Mercury Control," prepared by ADA-ES, Inc., have been posted:

  1. Quarterly period of April 1–June 30, 2005: http://www.netl.doe.gov/technologies/coalpower/ewr/mercury/control-tech/pubs/42307%20Q063005.pdf.

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- A quarterly progress report, "Amended Silicates for Mercury Control," prepared by Amended Silicates, LLC for the period of July 1–September 30, 2005 has been posted at http://www.netl.doe.gov/technologies/coalpower/ewr/mercury/control-tech/pubs/41988%20Q093005.pdf.

- A quarterly progress report, "Large-Scale Mercury Control Technology Testing For Lignite-Fired Utilities Oxidation Systems for Wet FGD," prepared by University of North Dakota Energy & Environmental Research Center for the period of July 1–September 30, 2005, has been posted at http://www.netl.doe.gov/technologies/coalpower/ewr/mercury/control-tech/pubs/41991%20Q093005.pdf.

- A quarterly progress report, "Evaluation of Sorbent Injection for Mercury Control," prepared by ADA-ES, Inc. for the period of October 1 December 31, 2005, has been posted at http://www.netl.doe.gov/technologies/coalpower/ewr/mercury/control-tech/pubs/41986%20Q123105.pdf.

- For additional information on NETL mercury related activities, please visit the Environmental & Water Resources' Mercury site located at http://www.netl.doe.gov/technologies/coalpower/ewr/mercury/index.html.